

DRAFT
**Packwood Lake Entrainment Study Report
for
Energy Northwest's Packwood Lake
Hydroelectric Project
FERC No. 2244
Lewis County, Washington**

Submitted to



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1.0 INTRODUCTION

Energy Northwest's Packwood Lake Hydroelectric Project, FERC No. 2244, received its initial license in 1960. The majority of the Project is located in the Gifford Pinchot National Forest. The Project consists of an intake canal, a concrete drop structure (dam) and intake building on Lake Creek located about 424 feet downstream from the outlet of Packwood Lake, a 21,691-foot system of concrete pipe and tunnels, a 5,621-foot penstock, a surge tank, and powerhouse with a 26,125 kW turbine generator.

The source of water for the Project, Packwood Lake, is a lake that pre-existed the Project, situated at an elevation of approximately 2,857 feet above mean sea level (MSL), about 1,800 feet above the powerhouse. Water discharged from the Project is released to the Cowlitz River via a tailrace channel. Power from the Project is delivered over an 8,009-foot 69 kV transmission line to the Packwood substation.

During the recreation season, May 1 through September 15, Packwood Lake is maintained at its approximate natural elevation (2,857 feet MSL). During the remainder of the year, the existing FERC license allows lowering the lake level not more than eight feet below the summer lake level down to an elevation of 2,849 feet MSL.

As part of the relicensing of the Packwood Lake Hydroelectric Project (FERC No. 2244), Energy Northwest was requested to evaluate the potential for fish entrainment at the Project intake structure. Fish entrained at the intake are removed from the lake population and no longer available for recruitment to the lake fishery.

The target species for the entrainment study are rainbow trout (*Oncorhynchus mykiss*) and coastal cutthroat trout (*O. clarki clarki*) in the adult life stage. It is assumed that rainbow trout would be most active in spring and travel the lake more extensively during their spawning period in search of suitable tributary spawning habitat. Rainbow trout spawning is thought to occur from June through early July in the Packwood Lake tributaries.

An entrainment study at the intake structure commenced during October, 2004. The results were very preliminary and it was determined that additional sampling was necessary before conclusions regarding the efficacy of the screens and the potential impacts of entrainment could be determined.

1.1 Study Plan Goals and Objectives

The goal of this study was to identify relative abundance, age/sex, timing and species composition of fishes entrained, impinged or otherwise affected by the Packwood Lake Hydroelectric intake structure. This information can be used to improve the knowledge base and develop an understanding of the options for natural resource protection, mitigation and enhancement.

Objectives of the Packwood Lake Hydroelectric Project Entrainment Study include:

- Determine species relative abundance, age/size, timing and composition at the intake structure.
- Evaluate the effectiveness of the Project's screens in terms of protecting fish.
- Assess the potential entrainment or impingement impacts from the lake elevation and Project flow fluctuations.
- Develop a rule curve for lake level elevation and diversion rate, since approach velocities may exceed the state criteria of 0.33 fps at some operating scenarios.

2.0 STUDY AREA AND METHODS

2.1 Study Area

The study area is the vicinity of the intake structure for the Packwood Lake Hydroelectric Project.

2.2 Methodology

The study was designed to determine the effectiveness of the existing screens at various flows, taking into account site-specific conditions of quantity and movement of bed load and debris. A description of how the screens are cleaned and the effects on screen approach velocity and control system logic when screens are partially plugged is provided in Section 3.1.1.

2.2.1 Engineering Criteria and Hydraulic Data

Energy Northwest provided engineering designs of the intake structure and hydraulic information related to lake levels, Project operational flows, and lake inflows during this period. The Project intake structure is shown in Figure 2.1.

2.2.2 Approach Velocities at the Intake

EES Consultants tested the efficacy of using an Acoustic Doppler Current Profiler (ADCP) to measure velocities in front of the intake screen in 2005. Tests indicated that the method was viable and had scheduled to use the ADCP throughout the 2006 field season. Windfall, snow, and high spill events in 2006, however, did not allow measurements to be taken until mid-July. Velocities were measured at the intake structure using the ADCP on July 19. After this date, lake elevation and project flows remained fairly constant, making additional measurements redundant (see Appendix A for further details). As a result, EES Consulting calculated mean screen velocities based upon screen surface area. EES Consulting will collect additional ADCP measurements during the winter – spring period, 2007 as conditions permit.

Mean screen velocities across the range of project flows and lake elevations were compared to the WDFW Screening Requirements for Water Diversions, as referenced in the Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual, August 2000; and the WDFW Draft Fish Protection Screens for Washington State (2000).

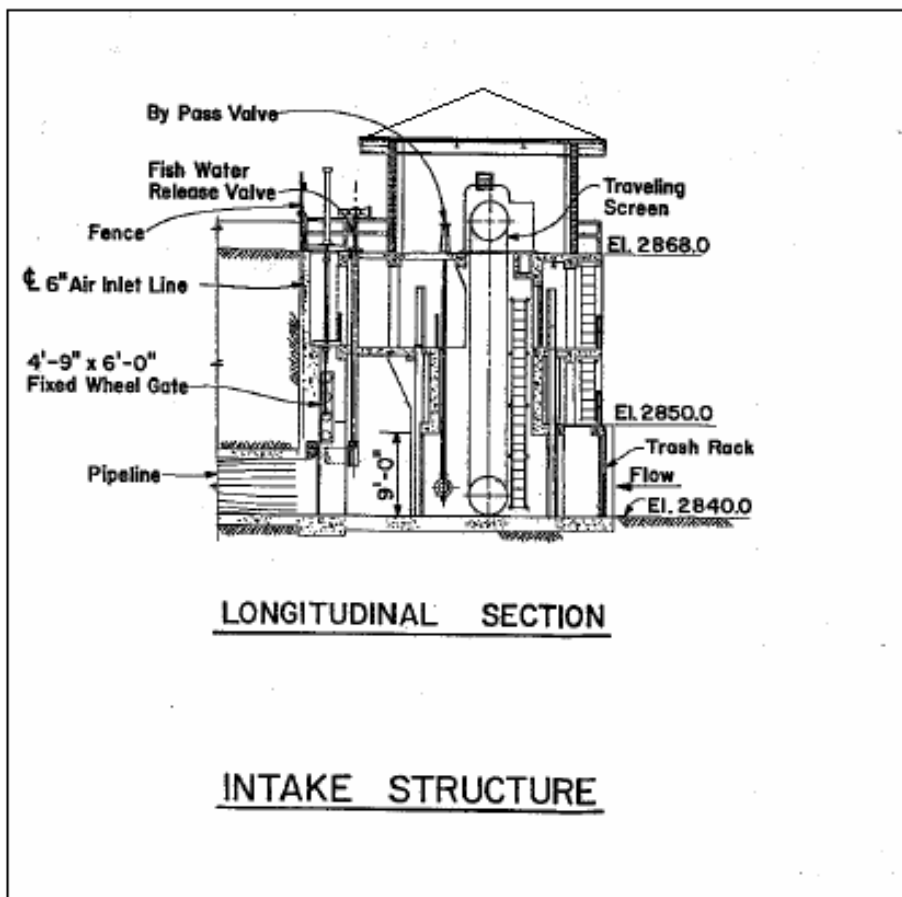


Figure 2-1. Schematic Drawing of Packwood Lake Intake Structure

2.2.3 Fisheries Investigations

An experimental, variable-mesh gillnet was deployed at the intake structure during the field season. Wind-throw and snow prevented setting the nets from February through May. High flow spill events, scheduled to provide additional information on the Lake Creek Instream Flow and Habitat Assessment, Fish Passage Barriers, Large Wood, and Gravel Transport studies, brought significant debris loads down to the intake structure. This debris clogged the net, making this effort ineffective. Therefore, netting was suspended until the flows subsided and the amount of debris accumulating near the intake decreased.

Lake levels and Project flows were recorded daily. The traveling screens were set to "Off" mode during the study. The traveling screens were rotated and any fish impinged on the screens were collected to determine the species, length, and condition (e.g. descaling, etc). These data were recorded in a log at the intake structure. The trash racks were raised monthly (when possible) for inspection to determine if any fish had been impinged. [Note: the trash racks were raised in April, August, September, and October. It was not possible the other months due to high lake elevations, high flow, or low visibility. No fish were impinged during the months inspected (R. Crawford, personal communications with W. Kiel, November 20, 2006)].

In the study plan, Energy Northwest proposed to have staff check the screens weekly during the March through September period weekly; however, wind-throw and snow prevented the staff from checking the screens systematically until May. Energy Northwest staff will therefore check the screens weekly in 2007 from March until May, assuming that access to the lake is available in March.

Energy Northwest had proposed in the study plan to mount underwater video cameras at the intake to observe fish behavior at the screens. As stated in the study plan, the effectiveness of this as a tool is dependent upon water clarity; if visibility was found to be poor due to high turbidity, the results during that period of time may be of limited use. Turbidity was high during the spill period and remained high until the end of July. EES Consulting did not use the cameras in 2006 due to the unusual set of conditions described above; rather, fish found on the screens were used as an indicator of assemblages near the intake structure. EES will attempt to use the camera again in 2007.

EES Consulting also interviewed the operators of the Project to obtain any written or oral historic information on entrainment that has been collected by Energy Northwest personnel.

3.0 RESULTS

3.1 Engineering Drawings and Hydraulic Criteria

3.1.1 Engineering Drawings

Energy Northwest reviewed the intake structure drawings to determine the size of the openings in the traveling screen at the intake structure. The screening over the intake structure is in the configuration of a 4X4 mesh (four meshes per inch in both the horizontal and the vertical). Wire mesh diameter is 0.080 inch, leaving openings 0.17 inch X 0.17 inch between the wires (4.3 mm X 4.3 mm).

Two screens provide protection to fish for the intake structure. Both structures are 9 ft in width and exceed 28 ft in height. The base elevation of the screens is 2840 ft MSL. A lake elevation of 2857 ft MSL at full pool results in a screen area of 306 ft² at full pool. During those time of the year when full pool was exceeded (e.g., during the spill events conducted for relicensing studies in 2006 or when inflows exceeded plant flows and the lake elevation was increased above 2857.0 ft MSL), the screen area increased.

The traveling screens are normally operated in an “automatic” mode. When the difference in water elevation across the screens is greater than 6 inches (adjustable), the screens turn on and rotate until the elevation is less than the set point or a fixed period of time has elapsed (about 5 minutes, adjustable). Small debris stuck on the screens is backwashed into the pipeline as the screens rotate.

3.1.2 Hydraulic Data

Appendix A includes daily lake elevation, plant flow, fish flow and lake inflow data for the period March 1 – September 30, 2006. Measurements are taken at 7 am daily and are an average of the previous 24 hour events. Screen velocities are a function of lake elevation (as a factor in screen area) and plant flow. These are further refined by inflows into Packwood Lake by lake tributaries, and regulatory constraints as discussed below.

Lake Elevations

During the recreation season, May 1 through September 15, Packwood Lake is maintained at its approximate natural elevation (2,857 feet MSL \pm 0.5 ft). During the remainder of the year, the existing FERC license allows lowering the lake level not more than eight feet below the summer lake level down to an elevation of 2,849 feet MSL. In 2006, Energy Northwest was granted a waiver of the license in order to provide spill flows downstream of the drop structure for the Large Wood, Gravel Transport, Lake Creek Instream Flow and Habitat Assessment, and Fish Passage Barriers studies. By providing these spill flows and also adhering to ramping rate restrictions, lake elevations during the May – July period varied significantly from the elevation prescription (See Figures 3-1 and 3-2). As a result, lake elevations were above the normal operating level for 70 days in 2006, beginning on April 30 when the Project began to stage for the spill event. Although the spill event was concluded on May 31, inflow from precipitation events and snow melt caused additional spills June 2 through June 9, June 13 through June 18, and higher than normal lake elevations until July 13, when plant flows and decreasing inflows allowed the Project to draw the lake down to below 2857.5 ft MSL for the summer season.

Plant Flows

The Packwood Lake Hydroelectric Project, on average, utilized 92 cfs of Packwood Lake inflow for power production for the March – September, 2006 period. Project flows ranged from 0 cfs diversion August 19-20 and September 2-4 when the Project was temporarily shut down (including for seining the stilling basin) to a maximum of 220 cfs, corresponding to maximum plant output, during periods of high inflow in June. Increased plant flows also occurred in late September when the lake was being drawn down prior to annual shutdown and maintenance (see Figures 3-3 and 3-4).

Lake Inflow

Lake inflow is a result of rain and glacial run-off into Packwood Lake. The major tributaries to Packwood Lake are Upper Lake, Muller, Crawford, Osprey, Trap and SE of Trap creeks. Upper Lake, Muller, and Crawford creeks provide the most significant flow to the lake.

Mean inflow to the lake for the March – September 2006 period was 98 cfs. September had the lowest inflow during this period, ranging from 13 – 35 cfs (mean 27 cfs) while June experienced the highest mean runoff (218 cfs). The highest daily inflow recorded was 455 cfs in May (Figure 3-5).

Screen Velocities

Screen velocities are a function of the amount of inflow going through the intake screen and the surface area of the screen itself; the surface area of the screen is a function of lake elevation.

Figure 3-6 shows a rating curve for mean screen velocities over a range of project flows (40 cfs – 220 cfs) and the operational levels of the project (El 2849 – 2860 MSL) calculated by dividing plant flow (cfs) by screen area (ft²). *[Note: since only one ADCP measurement was taken in 2006, velocities are as calculated based on plant flow and screen area rather than by ADCP measurements].* Velocities through the screens are highest at low lake elevations and high plant flows. By comparison, screen velocities are lower when lake elevations are held higher, due to increased surface area of the screens.

Screen velocities calculated during the 2006 period of record ranged from 0 ft/sec when the Project was shut down, to a high of 0.88 ft/sec in late September when the lake levels were low and the plant flow was high (See Figures 3-7 and 3-8). Mean monthly velocities were highest in June when the Project was lowering lake level from the spill events to meet summer elevation levels.

Figure 3-9 summarizes an analysis of mean screen velocities during the March – September, 2006 period. Over 50% of the time, mean screen velocities were less than 0.20 ft/sec; over 80% of the time, mean screen velocities were less than 0.50 ft/sec. Mean screen velocities exceeded 0.80 ft/sec less than 1% of the time. WDFW standards for intake structures in lakes are 0.33 ft/sec at the face of the screen. At the Packwood Lake intake structure, mean screen velocities are 0.33 ft/sec or less approximately 64% of the time.

EES Consulting recommended using an Acoustic Doppler Current Profiler (ADCP) to measure screen velocities in the Packwood Lake Entrainment Study Plan (EES Consulting 2005). Logistical problems (snow, access, high flows) prevented EES Consulting from securing meaningful measurements prior to July 2006; therefore Doppler measurements will continue into the 2007 field season to calibrate hypothetical rating curves on the screens to actual screen measurements.

3.2 Fisheries Investigations

3.2.1 Entrainment at the Intake Screens

Beginning in May 2006, Energy Northwest personnel rotated the intake screens on a weekly basis and noted and measured any fish found entrained on the intake screens. Conditions, as described above, prevented the study from beginning in March 2006 as planned. Energy Northwest will resume operating the screens in the manual mode and checking the screens weekly (access permitting) in March 2007 and will continue this effort through June 30, 2007.

The external trash screens were pulled and cleaned in April, August, September, and October. It was not possible to pull the trash racks during the other months due to high water elevation or high flow conditions. No fish were found on the trash screens during these inspections.

A total of 63 fish were found on the intake screens from May 23 through September 28, 2006 (Table 3-1; Figure 3-10). All fish found on the screens were rainbow trout. There were a total of 36 fish collected on Screen 1 and 27 fish collected on Screen 2.

The size of fish entrained on the intake screens averaged 194 mm, ranging from a minimum of 64 mm to 324 mm. Five fish (7%) were less than 100mm in length; over 76% of the rainbow trout (48) ranged from 161 mm – 240 mm (approximately 6.4 – 9.5 inches) (Figure 3-11).

Table 3-1 Rainbow Trout Mortalities on Packwood Lake Intake Screen, 2006		
Date	Screen 1	Screen 2
May 23	11	16
May 25	8	2
June 7	2	0
June 10	1	1
June 15	1	0
June 20	2	0
June 22	1	0
June 26	1	2
June 28	4	0
July 5	1	3
July 17	2	0
July 23	1	0
Sep 26	0	1
Sep 28	1	2
Total	36	27

Nearly 60% (37) of the fish were found on the screens during the two inspections in May. All of these fish exceeded 146 mm in length, averaging 206 mm. The maximum mean screen velocities during this period were 0.52 ft/second. Given the size of these fish, it is highly unlikely that healthy fish of this size would be impinged on the screens due to their swimming speeds. *[Note: see below for further details].*

Fish begin spawning in Packwood lake tributaries in late May. EES Consulting, as part of the Fish Distribution and Species Composition Study Plan (EES Consulting 2005b) fished Packwood Lake with gillnets on May 2nd and 3rd. Although nets were set out at dusk and retrieved at dawn per the study plan, 52 of the 106 fish captured were mortalities in the nets, with many of those released sustaining some level of injury. The status of these released fish is unknown, but it is likely that some may have experienced mortalities. Inflows to the lake during this period of time reached 455 cfs. These inflows, coupled with Project flows ranging from 131 – 179 cfs and lake elevations reaching 2859.65 ft (equating to a spill of 291 cfs) would facilitate transport of fish downstream, where they would float into the intake structure and be impinged on the screen. The timing of these events could be conducive to having the fish be found on the intake screens, although it is not known for certain.

Data on rainbow trout swimming speeds are lacking, but it seems reasonable that rainbow trout cruising, sustained and burst speeds would be comparable to those of cutthroat trout. Bell (1990) provided the cruising, sustained, and darting speeds for a variety of fish species. Cruising, sustained, and burst speeds for cutthroat trout are listed as 2.4 ft/sec, 6.0 ft/sec, and 13.5 ft/sec, respectively. Bell (1990) suggests that darting/burst speed can be maintained for 5 to 10 seconds. These assumed rainbow trout swimming and burst speeds (Bell 1990; Jain and Farrell 2003) far exceed the 0.52 ft/sec that were present at the intake screens during this period of time.

3.2.2 Experimental Gillnets in Front of Intake Structure

An experimental, variable-mesh gillnet was used to sample fish populations in the vicinity of the intake structure. The net used was 150 ft (45.7 m) long and 8 ft (2.4 m) deep with variously sized meshes ranging from ¼ in (6.4 mm) to 3 in (76.2 mm) stretched mesh.

Sampling protocol established in the Study Plan (EES Consulting 2005a) stated that the net would be deployed 3 to 4 times per month at a minimum of 2-day intervals from March through September, 2006 to monitor fish activity and behavior around this facility. The net was to be checked periodically (e.g., every 3 to 4 hours) during the daytime period every day that the net was deployed and in the morning hours after each nighttime set.

Snow, ice and lack of access to the lake prevented the nets from being deployed through May. In May, the combination of snowmelt, high lake inflows, and scheduled spill events resulted in high levels of debris being concentrated in the forebay area of the intake structure. Nets could not effectively be deployed because of high debris loads and clogging. These conditions continued through mid-July, when flows began recede and lake elevations were below the drop structure elevation (2858.50 ft MSL).

Gillnet sampling in front of the intake structure occurred on the following dates in 2006 (see Table 3-2):

- June: 29 – 30 (2 days)
- July 1; 19 – 20 (3 days)
- August 7 – 8; 23-24 (4 days)
- September 10-11) (2 days)

Three rainbow trout were captured during the June 29- July 1 sampling period and were released unharmed. No fish were captured during the other sampling periods.

In 2004, the following fish were captured in nets at the intake structure (Table 3-3).

Table 3-2 Fish Captured in Experimental Gillnet at Packwood Lake 2006		
Date	Species	Length (mm)
June 29	Rainbow trout	214
June 30	Rainbow trout	60
July 1	Rainbow trout	135
July 19	None	
July 20	None	
August 7	None	
August 8	None	
August 23	None	
August 24	None	
September 10	None	-
September 11	None	

Table 3-3 Fish Captured in Experimental Gillnet at Packwood Lake 2004			
Date	Species	Length (mm)	Water Temp (°C)
Oct. 13	Rainbow trout	203	13.3
	Rainbow trout	203	13.3
Oct. 14	Rainbow trout	229	13.3
Oct. 15	Rainbow trout	254	13.3
	Rainbow trout	229	13.3
Oct. 16	Rainbow trout	254	13.3
	Rainbow trout	279	13.3
	Rainbow trout	305	13.3
	Rainbow trout	305	13.3
Oct. 27	None	-	3.7

All salmonids observed in the lake, upper tributaries, and below the drop structure were rainbow trout. No cutthroat or other salmonids have been observed during studies.

3.2.3 Anecdotal Information of Project Entrainment

[Note: Energy Northwest is reviewing Project records to determine if entrainment on the intake screens has been noted in the past. The results of this review and interviews with Plant personnel will be included in the next draft].

Figure 3-1. Packwood Lake Monthly Elevations, 2006

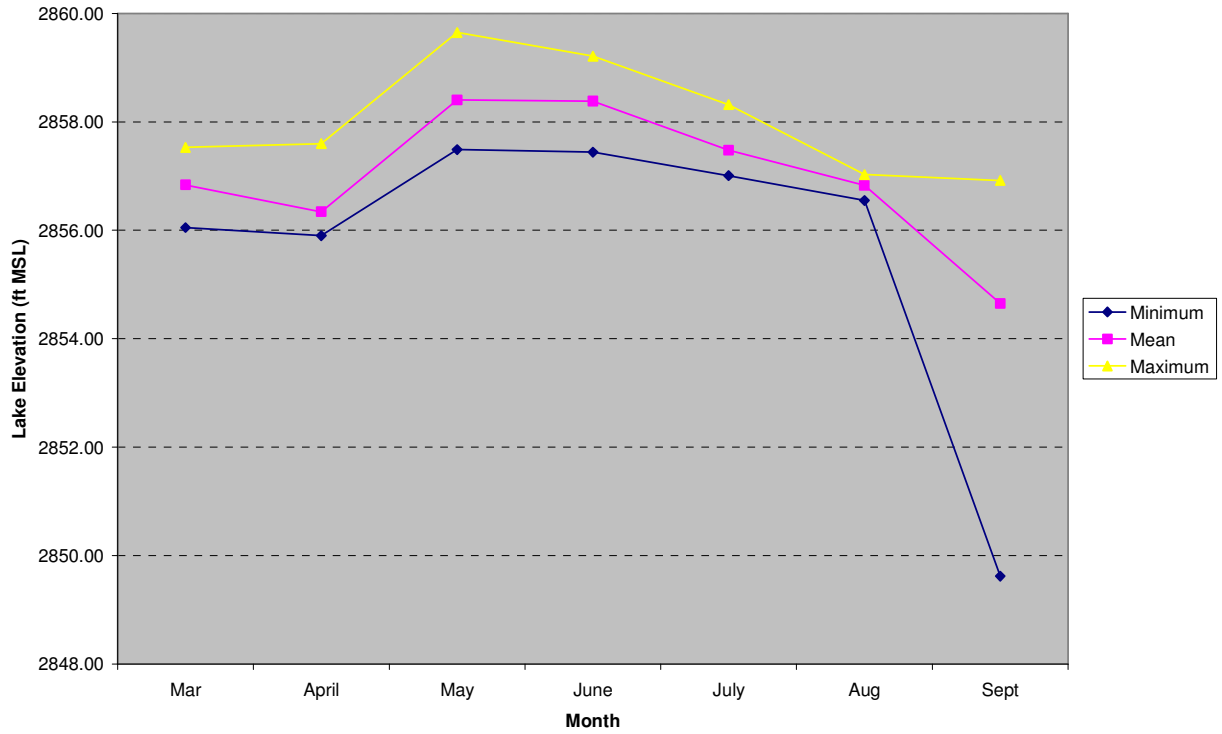


Figure 3-2. Mean Daily Lake Levels (ft)

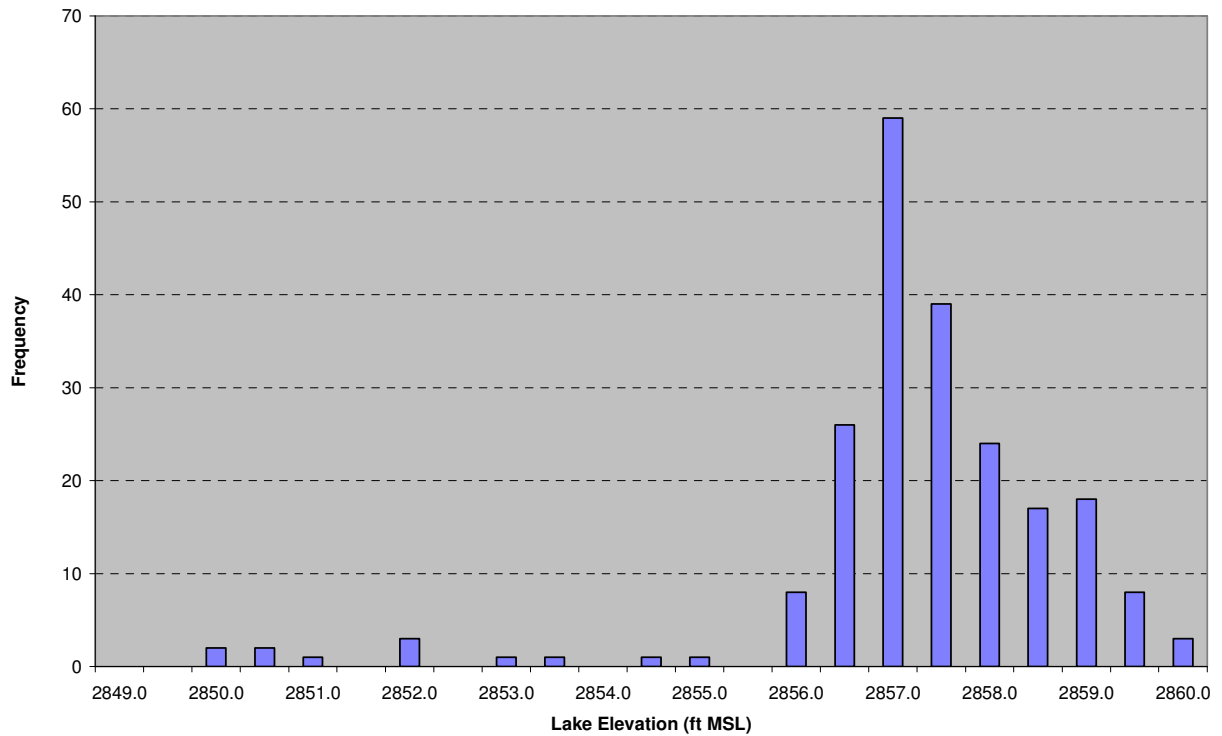


Figure 3-3. Monthly Plant Flows, Packwood Lake Project, 2006

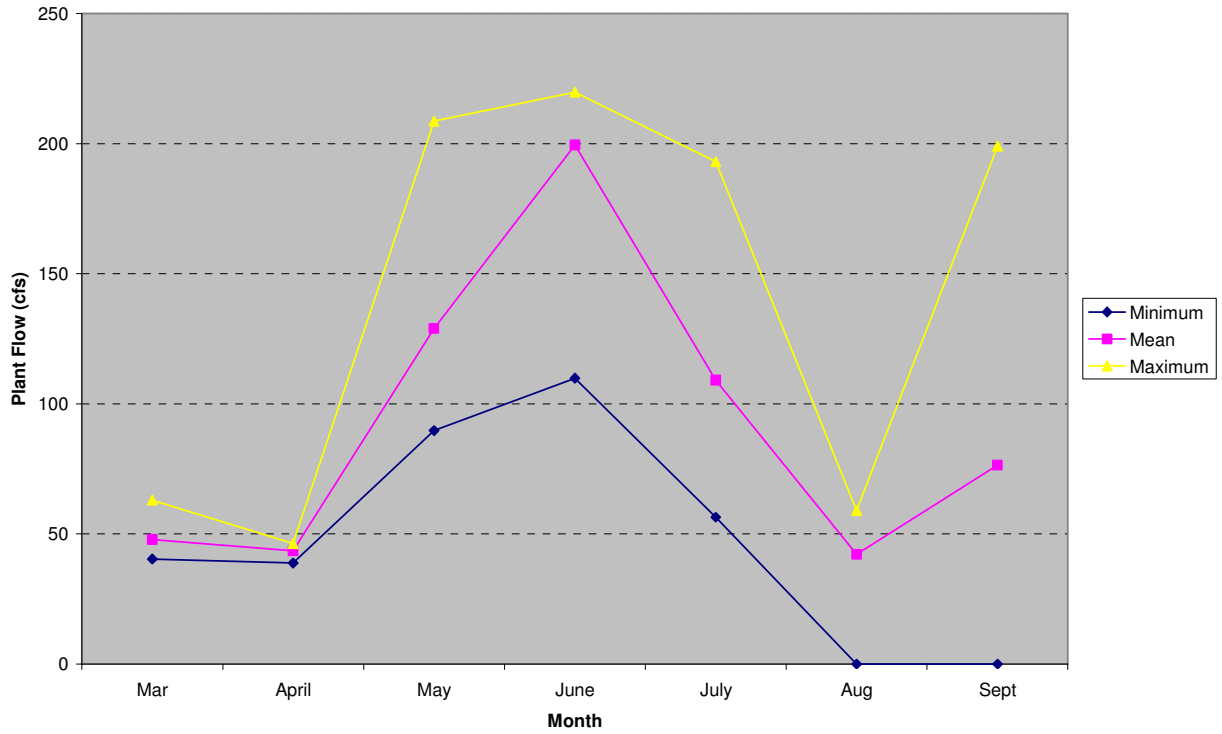


Figure 3-4. Packwood Lake Daily Plant Flow (cfs)

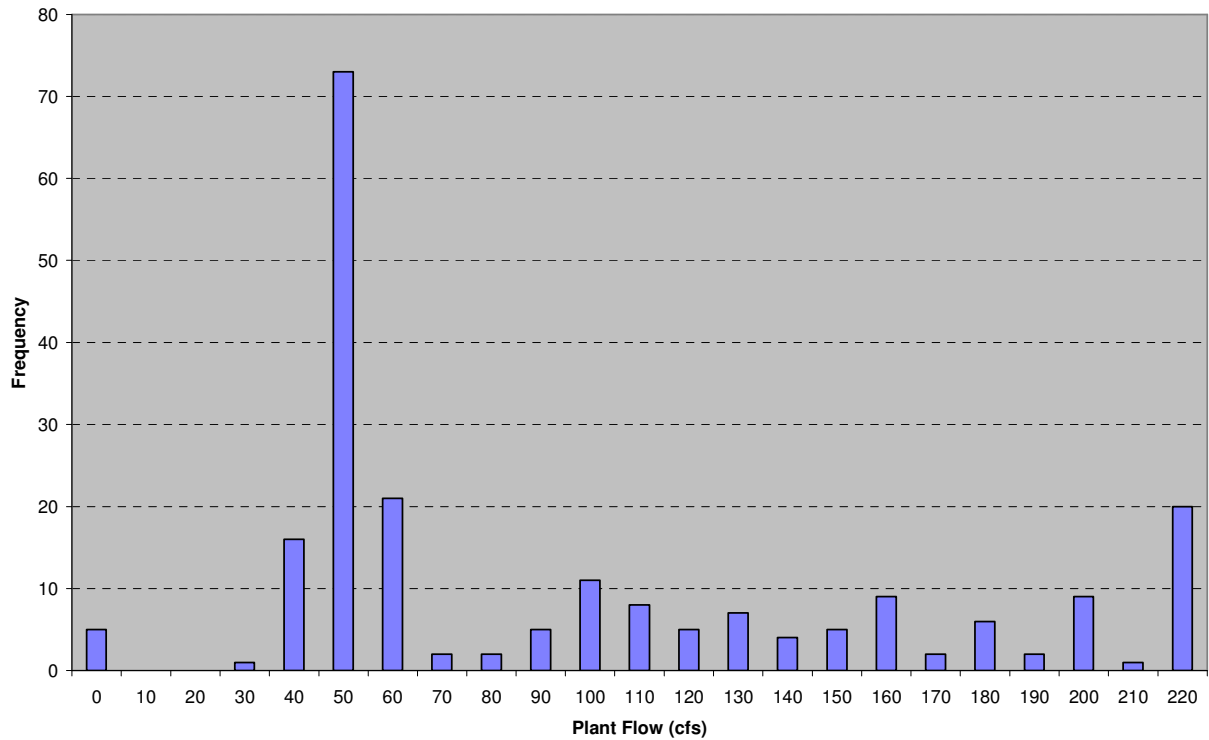


Figure 3-5. Monthly Inflow for Packwood Lake, 2006

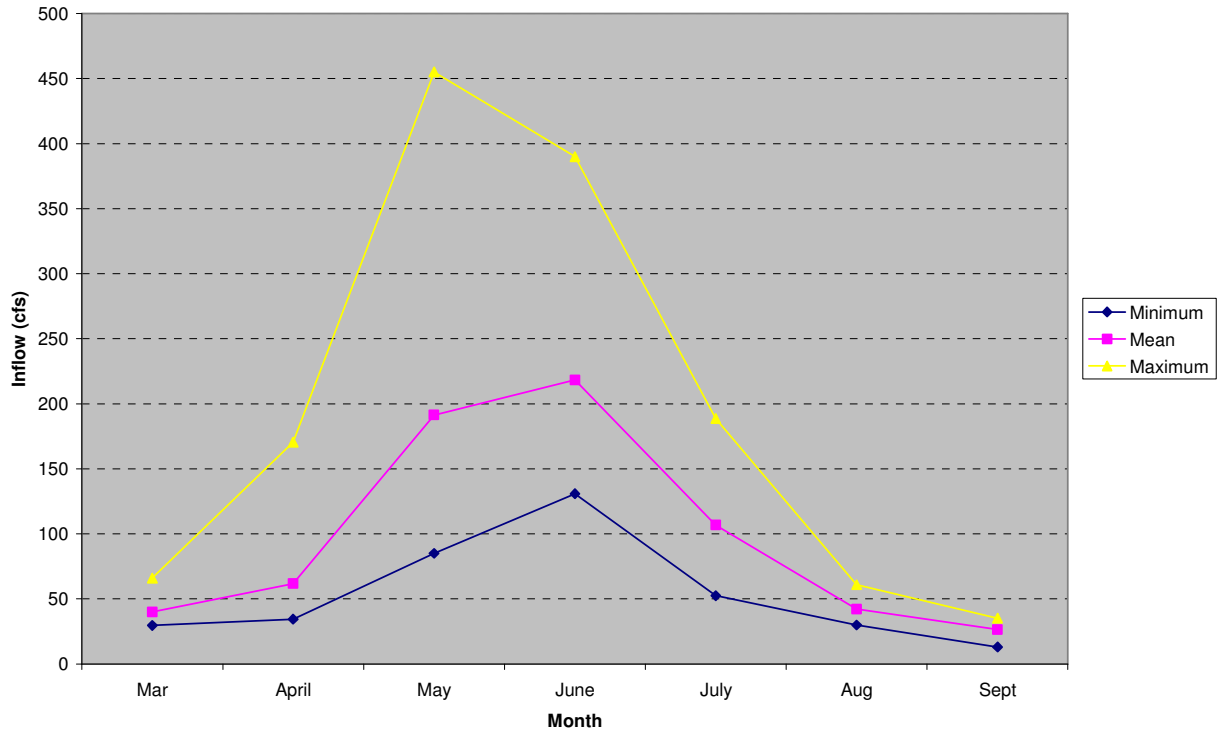


Figure 3-6. Mean Screen Velocities at Packwood Lake Intake Structure

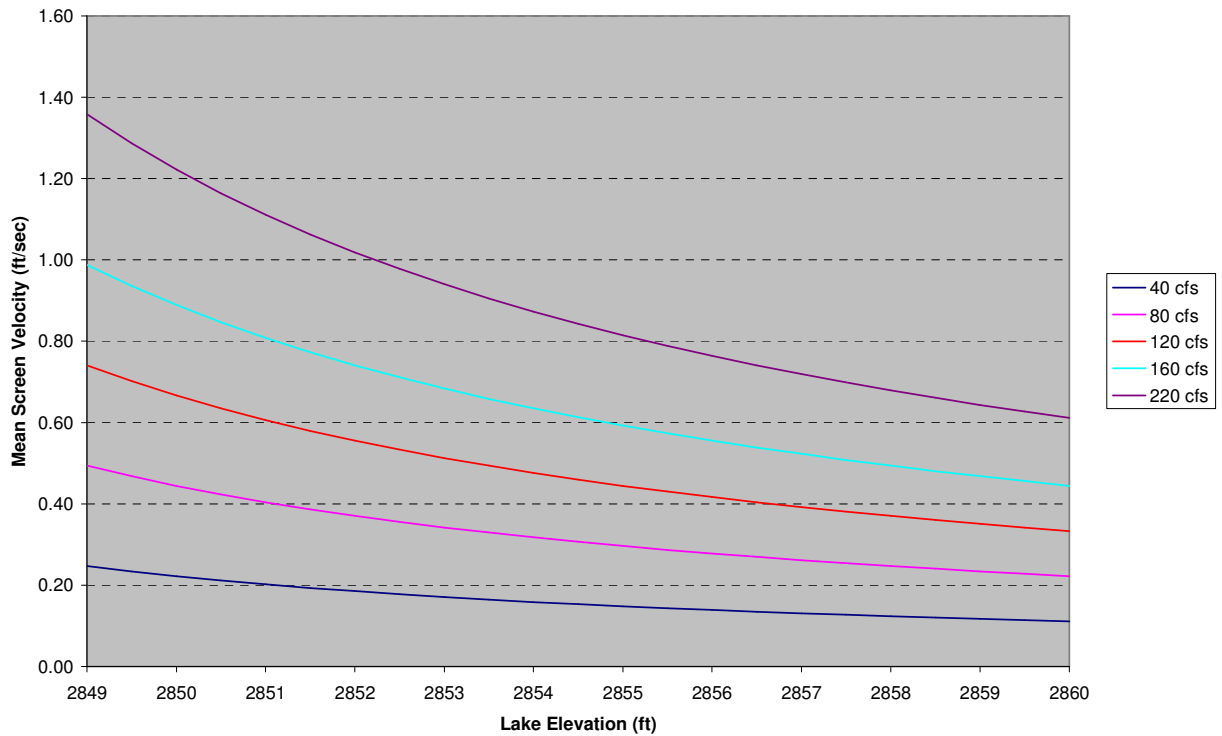


Figure 3-7. Mean Screen Velocities at Packwood Lake Intake Structure, 2006

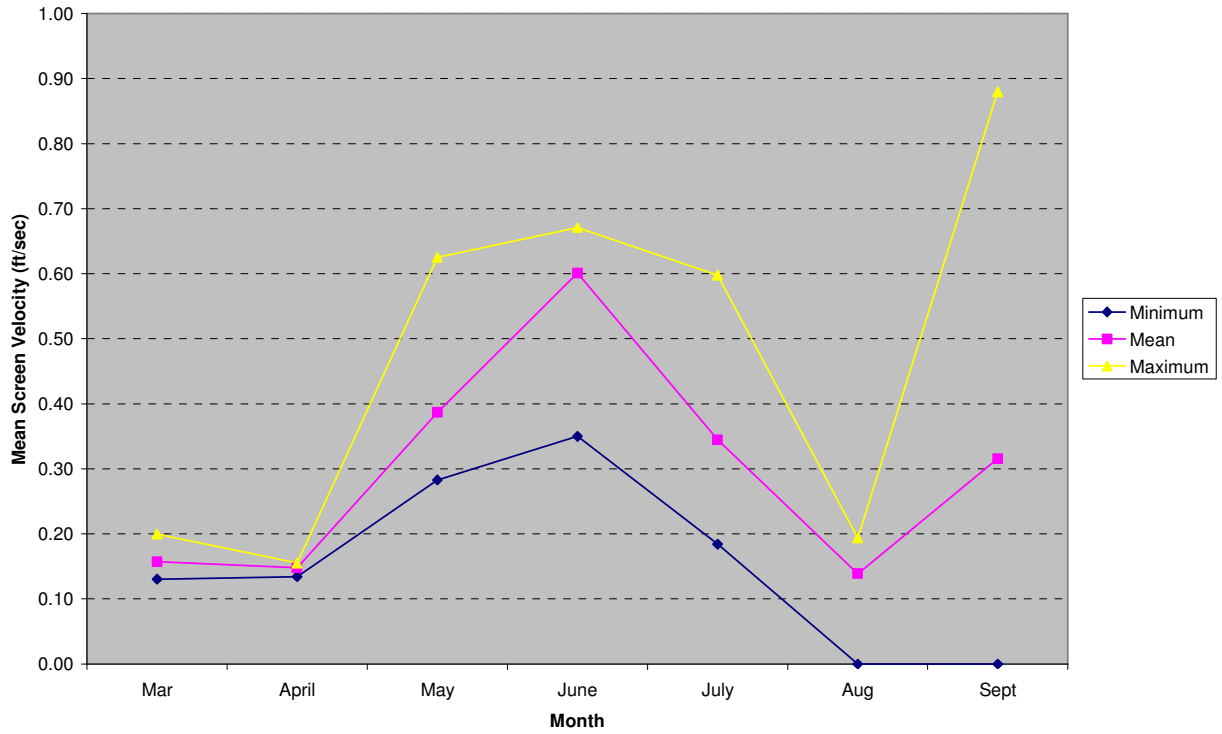


Figure 3-8. Mean Screen Velocities at Packwood Lake, 2006

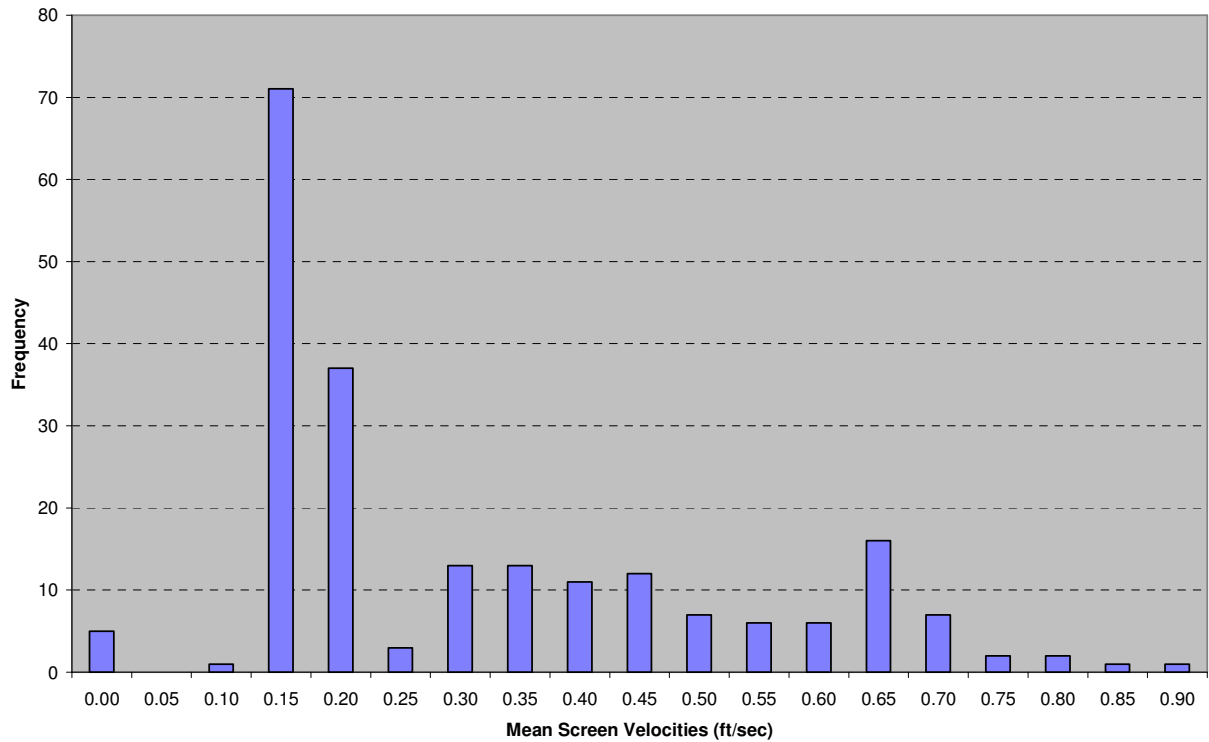


Figure 3-9. Screen Velocities at Packwood Lake Intake Structure

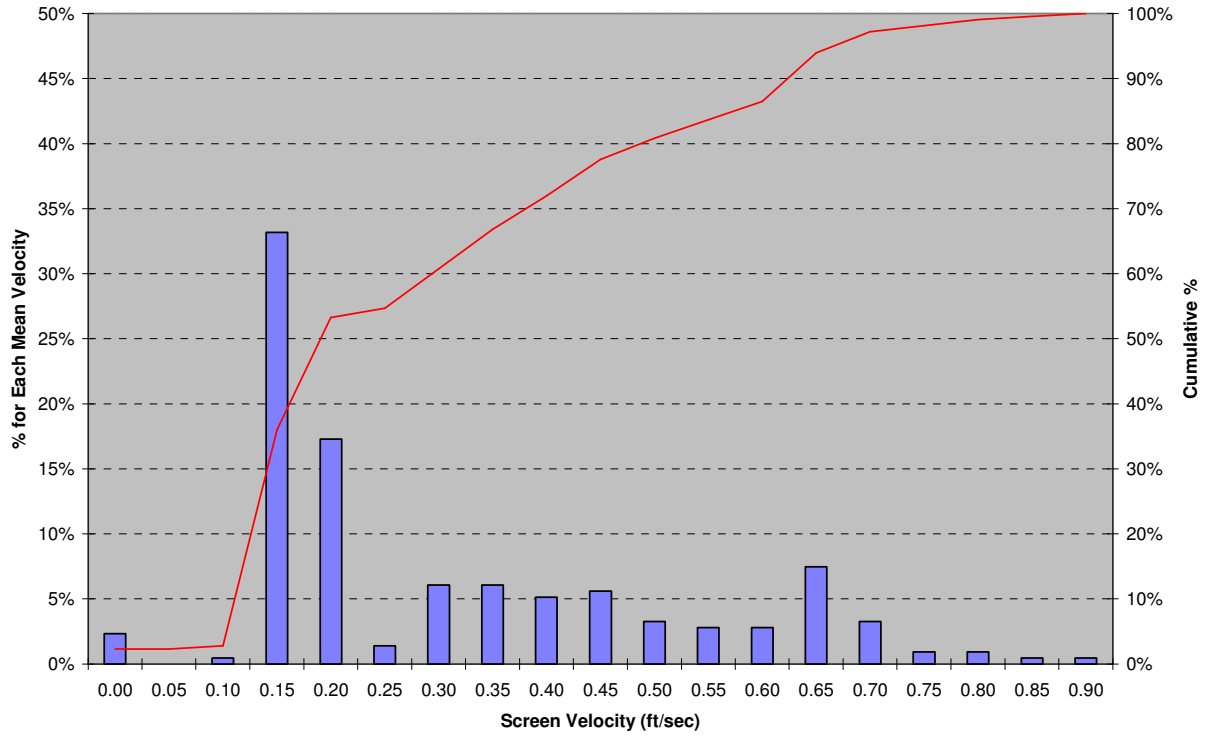


Figure 3-10. Packwood Lake Entrainment at Intake Screens (2006)

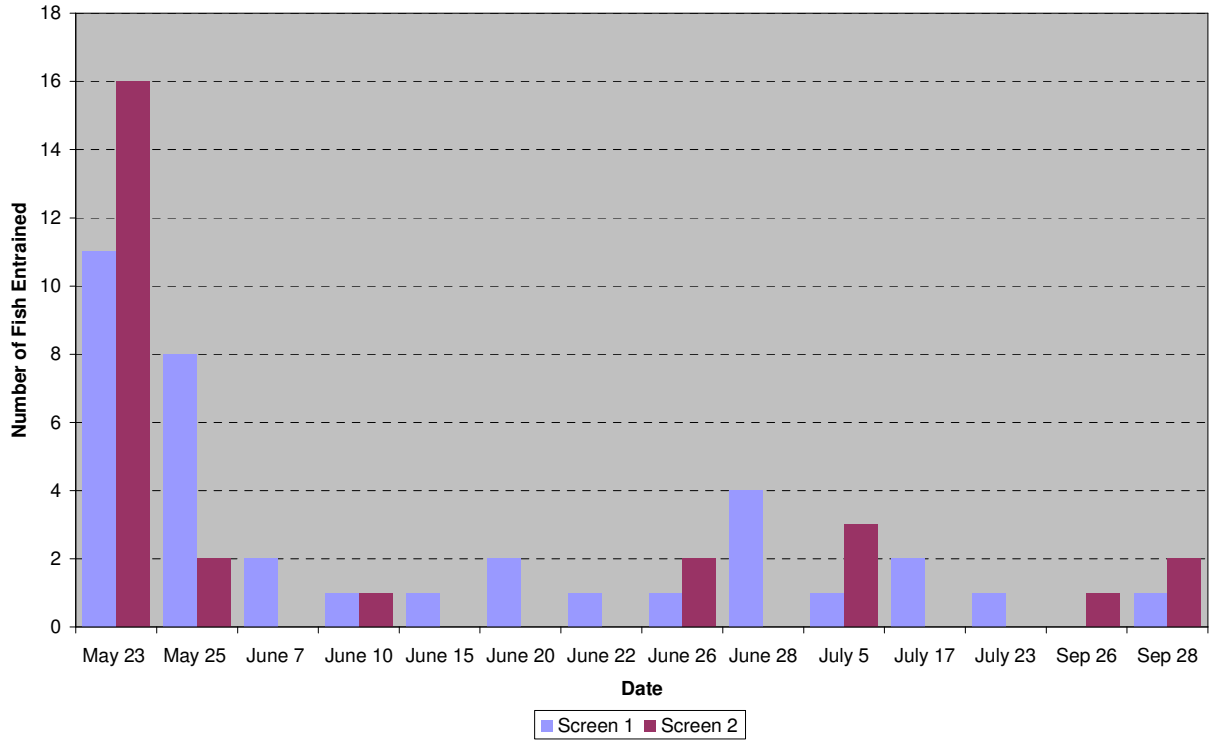
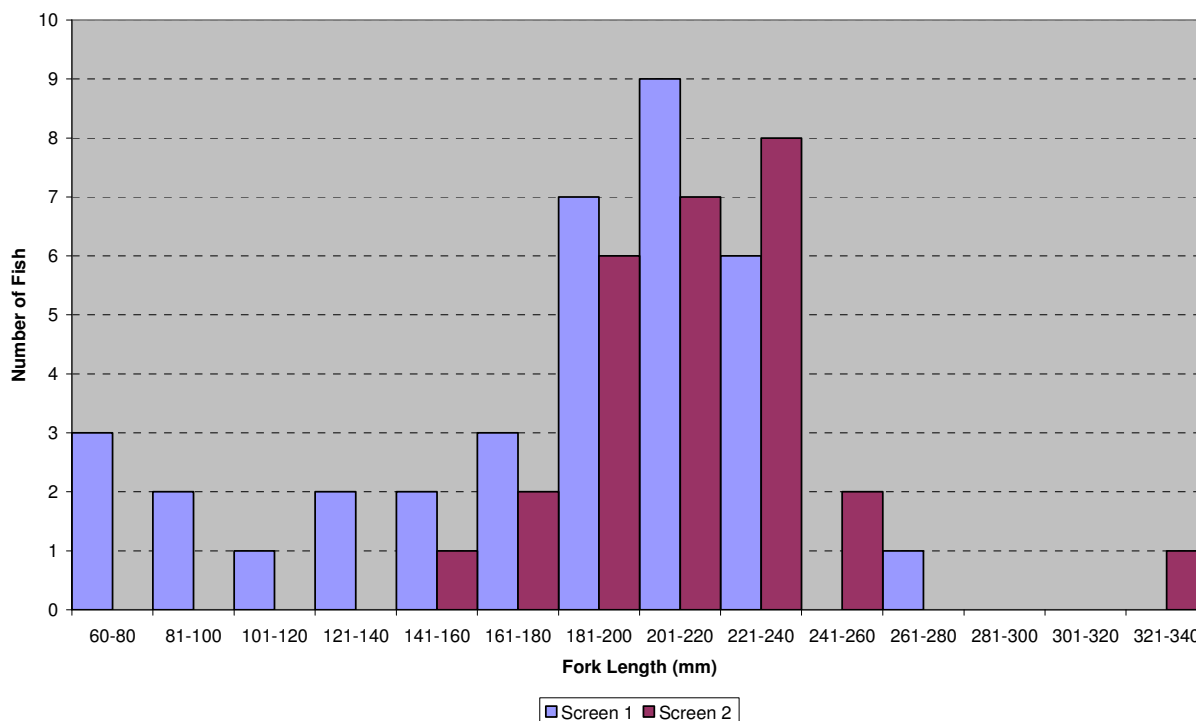


Figure 3-11. Packwood Lake Entrainment Data (2006)



4.0 DISCUSSION

Weather, access and spill events prevented EES Consulting from conducting early season sampling of the screens with the ADCP or conducting net sampling prior to late June and early July. Video monitoring of the screens proved challenging for the same reasons during this period of time.

Energy Northwest recommends that the entrainment study be continued through June, 2007. Weather, access and flows permitting, EES Consulting will conduct net sampling from March – June 30, 2007 and measure velocities across the intake screens at a variety of lake levels and flows. Monitoring of the intake screens will resume in 2007, beginning in March and extend until June 30, 2007. Videotaping will again be attempted in for the March – June period. A draft final report will be produced in July 2007 detailing the results of the study.

5.0 LITERATURE CITED

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APPENDIX A

DAILY FLOW STATISTICS FOR THE PACKWOOD HYDROELECTRIC PROJECT MARCH 1 – SEPTEMBER 30, 2006

Lake Levels and Operational Flows for Packwood Lake Hydroelectric Project, March - September, 2006						
Month	Day	Lake Level (ft)	Plant Flow (cfs)	Fish Flow (cfs)	Lake Inflow (cfs)	Mean Velocity (ft/sec)
March	1	2857.53	63	3.16	55	0.20
	2	2857.48	62	3.16	47	0.20
	3	2857.40	53	3.33	49	0.17
	4	2857.37	43	3.29	46	0.14
	5	2857.37	44	3.21	43	0.14
	6	2857.35	55	3.20	52	0.18
	7	2857.32	56	3.21	43	0.18
	8	2857.25	56	3.18	66	0.18
	9	2857.28	55	3.15	47	0.18
	10	2857.23	49	3.27	46	0.16
	11	2857.20	40	3.38	41	0.13
	12	2857.19	44	3.22	43	0.14
	13	2857.17	57	3.19	35	0.18
	14	2857.06	56	3.33	37	0.18
	15	2856.96	58	3.29	38	0.19
	16	2856.86	55	3.30	35	0.18
	17	2856.76	49	3.25	37	0.16
	18	2856.69	44	3.36	38	0.15
	19	2856.65	43	3.33	35	0.14
	20	2856.60	43	3.37	35	0.14
	21	2856.55	42	3.35	34	0.14
	22	2856.50	42	3.30	30	0.14
	23	2856.43	42	3.26	36	0.14
	24	2856.39	42	3.12	34	0.14
	25	2856.34	41	3.21	33	0.14
	26	2856.29	41	3.19	33	0.14
	27	2856.24	41	3.21	33	0.14
	28	2856.19	40	3.24	34	0.14
	29	2856.15	42	3.30	31	0.14
	30	2856.09	41	3.47	35	0.14
	31	2856.05	40	3.41	41	0.14
April	1	2856.04	39	3.43	38	0.13
	2	2856.02	40	3.33	35	0.14
	3	2855.98	43	3.40	47	0.15
	4	2855.98	44	3.26	40	0.15
	5	2855.95	44	3.25	43	0.15
	6	2855.93	44	3.24	43	0.15
	7	2855.91	43	3.30	44	0.15
	8	2855.90	44	3.20	70	0.15
	9	2856.00	43	3.27	53	0.15
	10	2856.03	42	3.14	52	0.14
	11	2856.06	43	3.22	46	0.15
	12	2856.06	45	3.06	55	0.16

Lake Levels and Operational Flows for Packwood Lake Hydroelectric Project, March - September, 2006						
Month	Day	Lake Level (ft)	Plant Flow (cfs)	Fish Flow (cfs)	Lake Inflow (cfs)	Mean Velocity (ft/sec)
	13	2856.09	43	3.12	64	0.15
	14	2856.17	42	3.14	75	0.14
	15	2856.30	43	3.16	62	0.15
	16	2856.37	44	3.04	54	0.15
	17	2856.40	43	3.10	53	0.15
	18	2856.43	43	3.20	51	0.15
	19	2856.45	44	3.11	47	0.15
	20	2856.45	45	3.22	55	0.15
	21	2856.48	44	3.40	59	0.15
	22	2856.53	44	3.38	59	0.15
	23	2856.58	42	3.34	52	0.14
	24	2856.61	44	3.40	52	0.15
	25	2856.63	44	3.35	59	0.15
	26	2856.68	46	3.35	59	0.15
	27	2856.72	44	3.20	61	0.15
	28	2856.78	44	3.42	111	0.15
	29	2857.06	44	3.50	170	0.14
	30	2857.60	45	3.44	147	0.14
May	1	2858.03	94	3.29	118	0.29
	2	2858.12	123	3.25	97	0.38
	3	2857.99	119	3.28	88	0.37
	4	2857.84	104	3.22	92	0.32
	5	2857.77	103	3.25	92	0.32
	6	2857.71	90	3.20	103	0.28
	7	2857.75	91	3.21	104	0.29
	8	2857.79	107	3.16	99	0.33
	9	2857.74	106	3.17	87	0.33
	10	2857.64	105	3.10	85	0.33
	11	2857.54	104	3.33	96	0.33
	12	2857.49	93	3.40	96	0.29
	13	2857.49	91	3.33	95	0.29
	14	2857.49	90	3.36	109	0.28
	15	2857.56	92	3.44	130	0.29
	16	2858.11	96	3.13	380	0.29
	17	2859.13	131	3.28	455	0.38
	18	2859.65	173	3.15	435	0.49
	19	2859.57	151	3.31	385	0.43
	20	2859.52	143	3.43	325	0.41
	21	2859.36	135	3.28	310	0.39
	22	2859.33	173	3.18	355	0.50
	23	2859.18	170	3.33	285	0.49
	24	2859.13	179	3.36	275	0.52
	25	2859.06	160	3.01	220	0.47
	26	2858.95	144	3.49	170	0.42

Lake Levels and Operational Flows for Packwood Lake Hydroelectric Project, March - September, 2006						
Month	Day	Lake Level (ft)	Plant Flow (cfs)	Fish Flow (cfs)	Lake Inflow (cfs)	Mean Velocity (ft/sec)
	27	2858.82	149	3.50	185	0.44
	28	2858.8	162	3.42	190	0.48
	29	2858.76	151	3.15	155	0.45
	30	2858.67	160	3.41	140	0.48
	31	2858.54	209	3.42	180	0.63
June	1	2858.41	220	3.41	271	0.66
	2	2858.62	219	3.33	315	0.65
	3	2858.90	219	3.36	260	0.64
	4	2858.84	215	3.24	390	0.63
	5	2859.21	215	3.31	315	0.62
	6	2859.10	213	3.36	265	0.62
	7	2858.94	216	3.30	245	0.63
	8	2858.82	217	3.33	200	0.64
	9	2858.62	216	3.32	165	0.65
	10	2858.38	213	3.48	153	0.64
	11	2858.10	164	3.36	181	0.50
	12	2858.16	196	3.10	329	0.60
	13	2858.73	217	3.10	270	0.64
	14	2858.81	220	3.10	255	0.65
	15	2858.79	220	3.10	265	0.65
	16	2858.82	220	3.10	260	0.65
	17	2858.81	220	3.10	210	0.65
	18	2858.64	220	3.10	161	0.65
	19	2858.37	220	3.10	143	0.66
	20	2858.02	198	3.10	139	0.61
	21	2857.75	160	3.10	133	0.50
	22	2857.62	160	3.10	131	0.50
	23	2857.48	141	3.10	135	0.45
	24	2857.44	110	3.10	177	0.35
	25	2857.72	142	3.10	223	0.45
	26	2858.06	211	3.10	246	0.65
	27	2858.20	220	3.10	237	0.67
	28	2858.26	220	3.10	173	0.67
	29	2858.04	188	3.38	146	0.58
	30	2857.84	177	3.48	156	0.55
July	1	2857.73	130	3.19	176	0.41
	2	2857.92	120	3.28	167	0.37
	3	2858.11	175	3.42	177	0.54
	4	2858.10	135	3.48	189	0.41
	5	2858.32	193	3.21	153	0.59
	6	2858.13	188	3.21	116	0.58
	7	2857.80	192	3.52	102	0.60
	8	2857.39	123	3.35	117	0.39
	9	2857.35	86	3.30	130	0.27

Lake Levels and Operational Flows for Packwood Lake Hydroelectric Project, March - September, 2006						
Month	Day	Lake Level (ft)	Plant Flow (cfs)	Fish Flow (cfs)	Lake Inflow (cfs)	Mean Velocity (ft/sec)
	10	2857.53	134	3.22	125	0.42
	11	2857.48	122	3.16	89	0.39
	12	2857.32	78	3.45	159	0.25
	13	2857.66	159	3.51	110	0.50
	14	2857.43	122	3.41	93	0.39
	15	2857.29	58	3.36	100	0.19
	16	2857.46	58	3.20	91	0.18
	17	2857.59	122	3.48	78	0.39
	18	2857.38	120	3.37	74	0.39
	19	2857.16	87	3.16	72	0.28
	20	2857.08	88	3.12	82	0.29
	21	2857.04	86	3.15	107	0.28
	22	2857.12	58	3.18	123	0.19
	23	2857.39	58	3.36	116	0.19
	24	2857.63	111	3.14	94	0.35
	25	2857.54	116	3.13	87	0.37
	26	2857.40	103	3.46	77	0.33
	27	2857.27	94	3.37	77	0.30
	28	2857.18	95	3.29	64	0.31
	29	2857.03	56	3.21	55	0.18
	30	2857.01	57	3.17	60	0.19
	31	2857.01	58	3.19	53	0.19
August	1	2856.97	56	3.19	48	0.18
	2	2856.92	59	3.36	53	0.19
	3	2856.88	58	3.24	50	0.19
	4	2856.83	53	3.25	47	0.17
	5	2856.79	42	3.38	50	0.14
	6	2856.81	39	3.25	54	0.13
	7	2856.86	45	3.23	51	0.15
	8	2856.87	46	3.21	52	0.15
	9	2856.88	46	3.28	61	0.15
	10	2856.93	44	3.33	48	0.15
	11	2856.93	45	3.20	49	0.15
	12	2856.93	47	3.27	43	0.15
	13	2856.90	47	3.23	44	0.16
	14	2856.87	44	3.14	43	0.15
	15	2856.85	45	3.15	39	0.15
	16	2856.81	44	3.20	40	0.14
	17	2856.78	43	3.16	41	0.14
	18	2856.76	44	3.17	36	0.15
	19	2856.71	0	3.18	37	0.00
	20	2856.86	0	3.48	42	0.00
	21	2857.03	44	3.44	38	0.14
	22	2856.99	45	3.24	37	0.15

Lake Levels and Operational Flows for Packwood Lake Hydroelectric Project, March - September, 2006						
Month	Day	Lake Level (ft)	Plant Flow (cfs)	Fish Flow (cfs)	Lake Inflow (cfs)	Mean Velocity (ft/sec)
	23	2856.94	45	3.16	35	0.15
	24	2856.88	42	3.16	36	0.14
	25	2856.84	44	3.16	38	0.14
	26	2856.80	44	3.11	38	0.14
	27	2856.76	43	3.15	31	0.14
	28	2856.69	43	3.10	30	0.14
	29	2856.62	43	3.08	30	0.14
	30	2856.55	32	3.11	35	0.11
	31	2856.55	30	3.13	33	0.10
September	1	2856.55	39	3.16	33	0.13
	2	2856.51	0	3.25	35	0.00
	3	2856.65	0	3.30	35	0.00
	4	2856.79	0	3.35	33	0.00
	5	2856.92	38	3.14	32	0.13
	6	2856.88	39	3.08	35	0.13
	7	2856.85	38	3.11	28	0.13
	8	2856.79	34	3.04	28	0.11
	9	2856.75	31	3.10	30	0.10
	10	2856.73	32	3.05	30	0.11
	11	2856.71	36	3.09	30	0.12
	12	2856.67	37	3.15	24	0.12
	13	2856.60	36	3.29	28	0.12
	14	2856.55	37	3.24	33	0.12
	15	2856.52	37	3.40	32	0.13
	16	2856.48	95	3.08	23	0.32
	17	2856.15	117	3.42	20	0.40
	18	2855.71	195	3.12	25	0.69
	19	2854.95	198	3.09	17	0.74
	20	2854.14	199	3.10	24	0.78
	21	2853.36	199	3.10	22	0.83
	22	2852.57	199	3.17	13	0.88
	23	2851.74	45	3.24	28	0.21
	24	2851.65	44	3.18	31	0.21
	25	2851.58	153	3.18	19	0.73
	26	2850.98	152	3.13	14	0.77
	27	2850.36	90	3.22	21	0.48
	28	2850.04	80	4.04	24	0.44
	29	2849.78	57	3.41	24	0.33
	30	2849.62	37	3.46	24	0.21